

ALTERNATIVES TO METHYL BROMIDE FUMIGATION FOR CONTROL OF SOIL BORNE DISEASES
IN BARE ROOT FOREST NURSERIES

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OUR OBJECTIVES ARE TO DEVELOP CULTURAL APPROACHES AIMED AT REDUCING POPULATIONS OF SOIL-BORNE PATHOGENIC FUNGI IN FOREST NURSERIES TO REPLACE CONVENTIONAL CHEMICAL FUMIGATION. ONE THREE-YEAR CYCLE OF THIS STUDY HAS BEEN COMPLETED IN SEVEN NURSERIES IN OREGON, CALIFORNIA, AND IDAHO. A SECOND CYCLE OF EXPERIMENTS HAS BEEN COMPLETED IN SIX NURSERIES. IN THE FIRST CYCLE, NON CHEMICAL, CULTURAL METHODS, INCLUDING BARE FALLOW AND ORGANIC SOIL AMENDMENTS, WERE COMPARED TO METHYL-BROMIDE AND OTHER CHEMICAL FUMIGANTS IN REDUCING PRE PLANT PATHOGEN POPULATIONS. BARE FALLOW, WITH OR WITHOUT PERIODIC TILLING WAS EQUIVALENT TO METHYL BROMIDE OR OTHER CHEMICAL FUMIGATION TREATMENTS IN REDUCING PREPLANT LEVELS OF *FUSARIUM OXYSPORUM* AND *PYTHIUM* SPP. SEEDLING DENSITY AND MORTALITY VARIED AMONG SEVERAL TREATMENTS, BUT AT ALL NURSERIES COMBINATIONS OF SOIL AMENDMENTS AND BARE FALLOWING YIELDED SEEDLING DENSITIES AND MORTALITIES EQUIVALENT OR SUPERIOR TO METHYL-BROMIDE OR OTHER CHEMICALLY FUMIGATED PLOTS. SAWDUST SOIL AMENDMENTS IN COMBINATION WITH BARE FALLOWING HAD A BENEFICIAL EFFECT OF DECREASING SEEDLING MORTALITY. FUMIGATION OF BARE FALLOW PLOTS WITH A SAWDUST SOIL AMENDMENT PROVIDED NO ADDITIONAL BENEFIT OVER JUST BARE FALLOW. ONE-YEAR OLD SEEDLINGS WERE ON AVERAGE LARGER AND HAD BETTER DEVELOPED ROOT SYSTEMS FROM METHYL BROMIDE FUMIGATED PLOTS, BUT AFTER THE SECOND GROWING SEASON DIFFERENCES IN SEEDLING PERFORMANCE WERE DIMINISHED. IN SEVERAL NURSERIES, TWO-YEAR-OLD SEEDLINGS FROM NON-FUMIGATED BARE FALLOW PLOTS WERE EQUIVALENT IN HEIGHT, CALIPER, AND ROOT DEVELOPMENT TO SEEDLINGS FROM METHYL BROMIDE FUMIGATED TREATMENTS. THESE TRENDS WERE REPEATED IN A SECOND STUDY CYCLE THROUGH TWO-YEAR OLD SEEDLINGS.

THE CULTURAL CYCLE EMPLOYED BY MANY BAREROOT NURSERIES, ESPECIALLY THOSE IN THE PACIFIC NORTHWEST, INCLUDES A TWO-YEAR PRODUCTION OF THE MAIN SEEDLING CROP FOLLOWED BY A SEASON OF COVER CROPPING. THE COVER CROP IS USUALLY INCORPORATED AS A GREEN SOIL AMENDMENT IN LATE SUMMER. THIS INPUT OF RICH ORGANIC MATTER CAN CAUSE SHARP INCREASES IN POPULATIONS OF SOIL FUNGI SUCH AS *F. OXYSPORUM*, WHICH HAVE THE CAPABILITY TO GROW SAPROBICALLY IN SOIL AND SURVIVE AT HIGH LEVELS IN SOIL OVER THE WINTER THROUGH FORMATION OF CHLAMYDOSPORES. HIGH PREPLANT POPULATIONS OF *F. OXYSPORUM* ARE FREQUENTLY ASSOCIATED WITH SUBSEQUENT DISEASE LOSSES.

MANY NURSERIES IN THE PACIFIC NORTHWEST CORRECT THIS PROBLEM BY FUMIGATING SOILS IN LATE SUMMER OR FALL AFTER INCORPORATING COVER CROPS. AN ALTERNATIVE IS TO OMIT THE COVER CROP AND GREEN MANURE INCORPORATION FROM THE CYCLE AND INSTEAD TO USE BARE FALLOWING TO REDUCE LEVELS OF FACULTATIVE PATHOGENS AND

PROMOTE HIGHER LEVELS OF NONPATHOGENS AND ANTAGONISTS TO PATHOGENS. ALTHOUGH FUMIGATION MAY ELIMINATE A NUMBER OF PEST PROBLEMS SIMULTANEOUSLY, ALTERNATIVES CAN BE DEVELOPED TO ADDRESS THE SPECIFIC NEEDS AT INDIVIDUAL

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NURSERIES BASED ON THEIR HISTORIES OF PEST PROBLEMS AND CULTURAL PRACTICES.
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REDUCTIONS IN DEPENDENCE ON CHEMICAL FUMIGATION DEPENDS ON DEVELOPMENT OF CULTURAL ALTERNATIVES THAT FAVOR MICROBIAL ANTAGONISTS OF PATHOGENS AND PROMOTE DIVERSE SOIL MICROBIAL COMMUNITIES.

GROWERS WHO ROUTINELY FUMIGATE HAVE FINE-TUNED WATERING, FERTILIZING, AND OTHER CULTURAL PRACTICES WITHIN A FUMIGATED SOIL SYSTEM. SEEDLINGS GROWN UNDER ALTERNATIVE SYSTEMS MAY BE LESS UNIFORM THAN THOSE GROWN IN SOIL FUMIGATED WITH METHYL BROMIDE/CHLOROPICRIN OR OTHER CHEMICAL FUMIGANTS. CULTURAL MODIFICATIONS, HOWEVER, SHOULD ENABLE FINE TUNING OF WATERING, FERTILIZATION, AND OTHER CULTURAL INPUTS AIMED AT IMPROVING SEEDLING PERFORMANCE IN THE ABSENCE OF FUMIGATION. MODIFICATION OF CULTURAL PRACTICES THAT CAN ALSO HELP REDUCE OR ELIMINATE THE NEED FOR SOIL FUMIGATION AND OTHER CHEMICAL PEST CONTROL. OUR RESULTS SHOW THAT BARE FALLOWING AND OTHER NON FUMIGATION APPROACHES CAN ACHIEVE COMPARABLE CONIFER SEEDLING DENSITIES, HEIGHTS, AND DIAMETERS. CULTURAL MODIFICATIONS SUCH AS TIME OF SOWING AND USE OF NON-SOIL SEED COVERING AT SOW CAN ALSO REDUCE DISEASE BY PRESENTING PHYSICAL AND TEMPORAL BARRIERS TO INFECTION. INCORPORATION OF SLOWLY DECOMPOSING ORGANIC SOIL AMENDMENTS MAY ENCOURAGE INCREASED POPULATIONS OF BENEFICIAL MICROORGANISMS.

IN THE TECHNOLOGY DEVELOPMENT PROJECT, "ALTERNATIVES TO CHEMICAL FUMIGATION IN BAREROOT FOREST NURSERIES," WE ARE CONCENTRATING ON MANAGEMENT OF SOIL-BORNE SEEDLING DISEASES. OUR GOAL IS TO ENABLE NURSERIES TO PRODUCE COMPARABLE CROPS WITH REDUCED OR ELIMINATED USE OF CHEMICAL SOIL FUMIGATION. SPECIFIC OBJECTIVES ARE TO PRODUCE SEEDLING CROPS HAVING SEEDBED DENSITIES AND SEEDLING QUALITY EQUIVALENT TO THOSE GROWN WITH CONVENTIONAL FUMIGATION.

NURSERIES HAVE THE CAPABILITY TO IMPLEMENT THESE MEASURES IMMEDIATELY AND AT REDUCED COST COMPARED TO ROUTINE CHEMICAL FUMIGATION. ADDITIONAL DISEASE PREVENTION MEASURES, SUCH AS BIOLOGICAL CONTROL SEED TREATMENTS CAN BE EXPECTED TO FURTHER REDUCE DISEASE INCIDENCE AND SEVERITY, IN COMBINATION WITH OTHER DISEASE AND PEST CONTROL MEASURES.

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TABLE 1. EFFECT OF TREATMENTS ON PPG COUNTS OF FUSARIUM AND PYTHIUM SPP. AT NURSERY 1.

TREATMENT	PRESOW FUSARIUM	D- FUSARIUM PERCENT	PRESOW PYTHIUM	D-PYTHIUM PERCENT
A NURSERY STANDARD, SD ¹ + N, TILL AS NEEDED, FALL BASAMID	866 A	- 87	4 A	- 60
B NO FUM, SD + N, FALLOW TILL AT 3-WEEK INTERVALS	7988 B	+ 17	60 B	+ 500
C NO FUM, SD + N, FALLOW NO TILL	4796 AB	- 29	45 B	+ 350
D NO FUM, NO SD, FALLOW WITH TILL	4303 AB	- 37	46 B	+ 360
E NO FUM, SAWDUST, NO N, FALLOW WITH TILL	2653 AB	- 61	46 B	+ 360

¹SD= SAWDUST AMENMENT

TABLE 2. TWO-YEAR OLD DOUGLAS-FIR SEEDLING QUALITY COMPARISONS BY TREATMENT AT NURSERY 1.

TREATMENT	SEEDLINGS /SQ FT.	MORTA LITY %	DIAMET ER	HEIGH T	ROOT AREA	SHOO T AREA
	SEP-96	SEP-96	MM	CM	SQ. CM	SQ. CM
A NURSERY STANDARD, SD ¹ + N, TILL AS NEEDED, FALL BASAMID	11.6 A	20.19 A	7.3 A	25.3	91.1	114.2
B NO FUM, SD + N, FALLOW TILL AT 3-WEEK INTERVALS	10.0 AB	34.19 B	7.3 A	26.2	96.3	116.3
C NO FUM, SD + N, FALLOW NO TILL	10.7 A	23.65 A	7.2 A	26.2	86.9	113.5
D NO FUM, NO SD, FALLOW WITH TILL	7.0 B	44.02 B	9.0 B	30.7	120.3	164.7
E NO FUM, SAWDUST, NO N, FALLOW WITH TILL	10.5 A	25.93 A	7.6 A	28.3	102.5	127.8

¹SD = SAWDUST AMENDMENT

SEEDLING QUALITY MULTIPLE COMPARISONS SHOW SIGNIFICANT DIFFERENCES IN DIAMETER ONLY, A DENSITY EFFECT DUE TO LOWER DENSITY WHERE THERE WAS SIGNIFICANT MORTALITY.

TABLE 3. TWO-YEAR OLD PONDEROSA PINE SEEDLING QUALITY COMPARISONS AT NURSERY 1.

TREATMENT	SEEDLINGS /SQ FT.	MORTA LITY %	DIAMET ER	HEIGH T	ROOT AREA	SHOO T AREA
	SEP-96	SEP-96	MM	CM	SQ. CM	SQ. CM
A NURSERY STANDARD, SD ¹ + N, TILL AS NEEDED, FALL BASAMID	15.40	9.80 AB	7.6	17.9	44.9	123.1
B NO FUM, SD + N, FALLOW TILL AT 3-WEEK INTERVALS	15.20	12.02 AB	7.9	17.3	51.4	122.4
C NO FUM, SD + N, FALLOW NO TILL	15.63	9.20 AB	7.1	16.2	45.1	104.5
D NO FUM, NO SD, FALLOW WITH TILL	13.46	14.00 A	7.9	16.7	51.0	122.5
E NO FUM, SAWDUST, NO N, FALLOW WITH TILL	15.73	7.37 B	8.0	17.9	50.1	126.6

¹SD= SAWDUST AMENDMENT

SEEDLING QUALITY, NO SIGNIFICANT DIFFERENCES AMONG TREATMENTS IN MULTIPLE COMPARISONS.

PERCENT MORTALITY, BUT NOT DENSITY, HAD SIGNIFICANT DIFFERENCES BETWEEN TREATMENTS D AND E.

TABLE 4. EFFECT OF TREATMENT ON FUSARIUM AND PYTHIUM PPG AT NURSERY 2.

TREATMENT	PRESOW FUSARIUM	D- FUSARIUM PERCENT	PRESOW PYTHIUM	D-PYTHIUM PERCENT
A COVER CROP, FUMIGATED MBR	1197	+ 52	16	- 45
B FALLOW WITH TILL	507	- 35	23	- 26
C FALLOW NO TILL	2228	+ 184	77	+ 234
E COVER CROP NO FUM	5090	+ 550	129	+ 460

TABLE 4. EFFECT OF TREATMENT ON SEEDLING QUALITY AT NURSERY 2.

TREATMENT	SEEDLINGS/ SQ FT.	2-0 SEEDLINGS			
		DIAMETE R	HEIGHT	ROOT AREA	SHOOT AREA
A COVER CROP, FUMIGATED MBR	15.7 A	MM 6.2 A	CM 19.3	SQ. CM 57.1 A	SQ. CM 93.1 A
B FALLOW WITH TILL	14.0 A	6.0 A	19.8	45.2 B	94.5 A
C FALLOW NO TILL	18.0 A	6.2 A	19.8	46.4 B	91.1 A
E COVER CROP NO FUM	6.1 B	7.8 B	18.6	68.0 C	115.1 B

NO SIGNIFICANT DIFFERENCES IN 2-0 SEEDLING HEIGHT.

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TABLE 5. EFFECT OF TREATMENT ON SEEDLING QUALITY AT NURSERY 5.

TREATMENT	SEEDLINGS/S Q FT.	DIAMETE R	HEIGHT
	OCT-97	MM	CM
A FALLOW, BASAMID FUMIGATION	27.1 A	5.0 A	21.0 A
B SAWDUST	29.7 AB	4.0 B	14.0 B
C BARE FALLOW, MONTHLY CULTIVATION	26.8 A	4.5 C	16.7 C
D BARE FALLOW, MONTHLY CULTIVATION	27.2 A	4.1 B	16.0 C
E SEWAGE SLUDGE AMENDMENT	33.2 AB	4.0 B	12.6 D
F BIOCONTROL AMENDMENT	37.8 B	4.1 B	15.6 C

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